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EXAMINER	
LANGMAN, JONATHAN C	

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Please find below and/or attached an Office communication concerning this application or proceeding.

The time period for reply, if any, is set in the attached communication.

Office Action Summary	Application No. 10/593,809	Applicant(s) NARAYAN ET AL.	
	Examiner JONATHAN LANGMAN	Art Unit 1784	

-- The MAILING DATE of this communication appears on the cover sheet with the correspondence address --

Period for Reply

A SHORTENED STATUTORY PERIOD FOR REPLY IS SET TO EXPIRE 3 MONTH(S) OR THIRTY (30) DAYS, WHICHEVER IS LONGER, FROM THE MAILING DATE OF THIS COMMUNICATION.

- Extensions of time may be available under the provisions of 37 CFR 1.136(a). In no event, however, may a reply be timely filed after SIX (6) MONTHS from the mailing date of this communication.
- If NO period for reply is specified above, the maximum statutory period will apply and will expire SIX (6) MONTHS from the mailing date of this communication.
- Failure to reply within the set or extended period for reply will, by statute, cause the application to become ABANDONED (35 U.S.C. § 133). Any reply received by the Office later than three months after the mailing date of this communication, even if timely filed, may reduce any earned patent term adjustment. See 37 CFR 1.704(b).

Status

1)☒ Responsive to communication(s) filed on *21 December 2011*.

2a)☐ This action is **FINAL**. 2b)☒ This action is non-final.

3)☐ An election was made by the applicant in response to a restriction requirement set forth during the interview on ____; the restriction requirement and election have been incorporated into this action.

4)☐ Since this application is in condition for allowance except for formal matters, prosecution as to the merits is closed in accordance with the practice under *Ex parte Quayle*, 1935 C.D. 11, 453 O.G. 213.

Disposition of Claims

5)☒ Claim(s) *29-41* is/are pending in the application.

5a) Of the above claim(s) ____ is/are withdrawn from consideration.

6)☐ Claim(s) ____ is/are allowed.

7)☒ Claim(s) *29-41* is/are rejected.

8)☐ Claim(s) ____ is/are objected to.

9)☐ Claim(s) ____ are subject to restriction and/or election requirement.

Application Papers

10)☐ The specification is objected to by the Examiner.

11)☐ The drawing(s) filed on ____ is/are: a)☐ accepted or b)☐ objected to by the Examiner.

Applicant may not request that any objection to the drawing(s) be held in abeyance. See 37 CFR 1.85(a).

Replacement drawing sheet(s) including the correction is required if the drawing(s) is objected to. See 37 CFR 1.121(d).

12)☐ The oath or declaration is objected to by the Examiner. Note the attached Office Action or form PTO-152.

Priority under 35 U.S.C. § 119

13)☐ Acknowledgment is made of a claim for foreign priority under 35 U.S.C. § 119(a)-(d) or (f).

a)☐ All b)☐ Some * c)☐ None of:

1.☐ Certified copies of the priority documents have been received.

2.☐ Certified copies of the priority documents have been received in Application No. ____.

3.☐ Copies of the certified copies of the priority documents have been received in this National Stage application from the International Bureau (PCT Rule 17.2(a)).

* See the attached detailed Office action for a list of the certified copies not received.

Attachment(s)

1) ☒ Notice of References Cited (PTO-892)

2) ☐ Notice of Draftsperson's Patent Drawing Review (PTO-948)

3) ☐ Information Disclosure Statement(s) (PTO/SB/08) Paper No(s)/Mail Date ____.

4) ☐ Interview Summary (PTO-413) Paper No(s)/Mail Date. ____ .

5) ☐ Notice of Informal Patent Application

6) ☐ Other: ____.

DETAILED ACTION

Continued Examination Under 37 CFR 1.114

A request for continued examination under 37 CFR 1.114, including the fee set forth in 37 CFR 1.17(e), was filed in this application after final rejection. Since this application is eligible for continued examination under 37 CFR 1.114, and the fee set forth in 37 CFR 1.17(e) has been timely paid, the finality of the previous Office action has been withdrawn pursuant to 37 CFR 1.114. Applicant's submission filed on December 21, 2011 has been entered.

Claim Rejections - 35 USC § 112

Claims 29-33, 38, and 40 are rejected under 35 U.S.C. 112, first paragraph, as failing to comply with the enablement requirement. The claim(s) contains subject matter which was not described in the specification in such a way as to enable one skilled in the art to which it pertains, or with which it is most nearly connected, to make and/or use the invention.

Claim 29 sets forth a tantalum film disposed on a silicon substrate, wherein the film has a single crystal microstructure with an x-ray diffraction peak at $2\theta=55^{\circ}$.

As is known in the art, single crystal alpha tantalum has a diffraction peak at $2\theta=55^{\circ}$ which corresponds to the alpha tantalum 200 spot. See at least Figures 5-7 of Fartash (US 6,955,835).

The instant specification discloses in Figure 2 that when alpha tantalum is deposited on silicon the x-ray diffraction peak at $2\theta=55^{\circ}$ does not exist.

Therefore the specification has not enabled one of ordinary skill in the art at the time of the present invention to make the invention, more specifically a single crystal tantalum film on a silicon substrate with the claimed x-ray diffraction characteristics. The specification does not disclose what processes are needed in order to achieve the claimed x-ray characteristics for alpha tantalum when deposited on silicon, or if the claimed x-ray characteristics are even obtainable when alpha tantalum is deposited on silicon according to the methods disclosed for the instant invention.

Claims 30-33, 38, and 40 are rejected for being dependent upon a base rejected claim.

Claim Rejections - 35 USC § 102

The following is a quotation of the appropriate paragraphs of 35 U.S.C. 102 that form the basis for the rejections under this section made in this Office action:

> A person shall be entitled to a patent unless –
>
> (b) the invention was patented or described in a printed publication in this or a foreign country or in public use or on sale in this country, more than one year prior to the date of application for patent in the United States.

Claims 34-37, 39, and 41 are rejected under 35 U.S.C. 102(b) as anticipated by or, in the alternative, under 35 U.S.C. 103(a) as obvious over Ding et al. (US 6,057,237).

Ding et al. teach a silicon substrate (col. 1, lines 18-22), upon which is deposited a silicon oxide dielectric. Within a trench opening in the dielectric, alternating layers of amorphous tantalum and amorphous tantalum nitride are formed (col. 2, lines 30-45). The tantalum nitride can be formed as the first layer followed by a tantalum thereon (col.

2, lines 50-53). The deposition results in a wholly amorphous multilayer stack of alternating layers of TaN and Ta (col. 3, lines 4). A copper layer is formed thereon and the amorphous barrier layer prevents diffusion of copper into an adjacent dielectric material (col. 1, lines 54-61 and col. 3, lines 4-10). A dense, wholly amorphous layer, will inherently have no grain boundaries.

Ding et al. are silent to a diffuse ring in the electron diffusion pattern as well as a diffuse x-ray diffraction peak at two theta = 30-35°, however these characteristics are inherent to amorphous tantalum films. Where the claimed and prior art products are produced by identical or substantially identical processes, the Patent and Trademark Office can require an applicant to prove that the prior art products do not necessarily or inherently possess the characteristics of the claimed product. Whether the rejection is based on "inherency" under 35 U.S.C. § 102, or "prima facie obviousness" under 35 U.S.C. § 103, jointly or alternatively, the burden of proof is the same, and its fairness is evidenced by the inability of the Patent and Trademark Office to manufacture products or obtain and compare prior art products. *In re Best,* 562 F.2d 1252, 1255 (CCPA 1977).

The mere recitation of a newly discovered property, inherently possessed by things in the prior art, does not cause a claim drawn to those things to distinguish over the prior art. In re Swinehart, 439 F.2d 210, 212-13 (CCPA 1971).

Since Ding et al. teach the same amorphous tantalum film as instantly claimed, it is expected that it will possess the same material characteristics, i.e. x-ray diffraction pattern and diffuse ring.

Regarding claims 36 and 37, Ding et al. are silent to the net diffusion characteristics of the annealed structure, however, if the structure of Ding were annealed at 650-750°C for one hour, the film would inherently possess a net diffusion distance of less than 10 nms, as instantly claimed, as it has been held that similar materials will yield similar results (see in re best case law applied above).

Regarding claims 35 and 37, Ding et al. are silent to the resistivity of the tantalum, film, however, the discrete layer of amorphous tantalum, is expected to have the same resistivity instantly claimed (i.e. 250-275 micro ohm-cm), as a material and its properties are inseparable (see in re best case law applied above).

Claim Rejections - 35 USC § 103

The following is a quotation of 35 U.S.C. 103(a) which forms the basis for all obviousness rejections set forth in this Office action:

> (a) A patent may not be obtained though the invention is not identically disclosed or described as set forth in section 102 of this title, if the differences between the subject matter sought to be patented and the prior art are such that the subject matter as a whole would have been obvious at the time the invention was made to a person having ordinary skill in the art to which said subject matter pertains. Patentability shall not be negatived by the manner in which the invention was made.

Claim 38 is rejected under 35 U.S.C. 103(a) as being unpatentable over Stavrev et al. ("Behavior of thin Ta-Based films in the Copper/barrier/Si system") in view of Menzel et al. (US 4,372,989).

Stavrev et al. teach methods of making an ideal diffusion barrier system between copper and silicon. Stavrev et al. teach that the barrier performance relies upon the grain boundaries, and teaches that nanocrystalline, amorphous, and single crystal tantalum films would provide the highest amount of barrier performance (see figure 2, and discussion on page 994). Stavrev et al. go on to teach methods of achieving amorphous and nanocrystalline tantalum films (Table 1, pg. 995, and abstract), but fail to teach a specific example employing single crystal tantalum films. Stavrev et al. teach that the high temperatures required to form single crystalline refractory films do not have any practical application in the semiconductor industry.

Menzel et al. teach a similar concept to Stavrev et al., in that high temperature annealing to form desired crystallinity in tantalum is undesirable in semiconductor structures (col. 1, lines 35-50). Menzel et al. teach a method that avoids these high temperatures and allows for methods of forming monocrystalline tantalum films on silicon substrates (abstract and examples 1 and 2 (col's 4 and 5)). While Menzel et al. teach localized regions of monocrystalline tantalum such as lines and shapes, Menzel et al. also teach that any shaped monocrystalline region can be made (col. 4, lines 45-50 and col. 5, lines 25-35).

It would have been obvious to use the methods of Menzel et al. to obtain single crystal tantalum films for copper diffusion barriers on silicon substrates, as Menzel et al.'s method allows for lower temperature conversion to single crystalline tantalum, which will not adversely affect the already formed structure. .

Although, Menzel does not teach that the single crystal tantalum film has a x-ray diffraction peak at two theta = 55° and characteristic (100) spot diffraction pattern and having no grain boundaries, these characteristics are all inherent to single crystal tantalum films, and are intrinsically present within the single crystal film of Menzel. (See in re best case law applied above).

Claim 40 is rejected under 35 U.S.C. 103(a) as being unpatentable over Stavrev et al. (Behavior of thin Ta-Based films in the Copper/barrier/Si system) in view of Menzel et al. (US 4,372,989), as applied to claim 38 above, in view of Woo et al. (US 6,531,780).

As described above, Stavrev modified by Menzel et al. teach a silicon substrate upon which is deposited a single crystal tantalum barrier layer, upon which is deposited a copper metallization. Stavrev and Menzel fail to teach forming a TiN or TaN layer in between the silicon substrate and the tantalum layer.

Woo et al. teach semiconductor devices comprising barrier layers of tantalum for copper metallizations (col. 4, lines 50-55, and col. 6, lines 7-15). Woo go on to teach that tantalum nitride and titanium nitride may be used as adhesion layers between the tantalum barrier layers and the silicon semiconductor substrate (col. 2, lines 58-60; col. 4, lines 25-40; and col. 6, lines 7-15).

It would have been obvious to insert tantalum nitride or titanium nitride between the tantalum layers and the silicon substrate of Stavrev modified by Menzel et al., as

Woo et al. has shown that these nitride layers are known in the art to provide better adhesion for tantalum diffusion layers.

Claims 29-33 are rejected under 35 U.S.C. 103(a) as being unpatentable over Marcus ("Electrical and Structural Properties of Epitaxial bcc Tantalum Films") in view of Menzel et al. (US 4,372,989).

Regarding claims 29 and 30, Marcus et al. teach thin films of epitaxial single crystal films of tantalum formed on a substrate of cleaved MgO. The tantalum films are body centered cubic (bcc) and have a resistivity of 16 micro ohm–cm, indicative of alpha phase tantalum (title, abstract and "introduction" section). Marcus teaches that electron diffraction patterns were obtained and only single crystal diffraction patterns were observed, thus the film is said to have characteristic (100) spot diffraction patterns, as instantly claimed (pg 3122, col. 2). Marcus goes on to teach that quenching from a high temperature results in a smooth single crystal film, with only dislocations present (i.e. no large angle boundaries are present) ("summary" section, pg 3127).

Marcus is silent to the tantalum film being characterized by an X-ray diffraction peak at two theta = 55°. However this characteristic is inherent to the single crystal tantalum film of Marcus since it has been held that similar materials possess similar properties and characteristics. Where the claimed and prior art products are produced by identical or substantially identical processes, the Patent and Trademark Office can require an applicant to prove that the prior art products do not necessarily or inherently possess the characteristics of the claimed product. Whether the rejection is based on

"inherency" under 35 U.S.C. § 102, or "prima facie obviousness" under 35 U.S.C. § 103, jointly or alternatively, the burden of proof is the same, and its fairness is evidenced by the inability of the Patent and Trademark Office to manufacture products or obtain and compare prior art products. *In re Best,* 562 F.2d 1252, 1255 (CCPA 1977).

The mere recitation of a newly discovered property, inherently possessed by things in the prior art, does not cause a claim drawn to those things to distinguish over the prior art. In re Swinehart, 439 F.2d 210, 212-13 (CCPA 1971). In the present case Marcus discloses single crystal tantalum films with the same resistivities, same diffraction characteristics, and same cubic structure; therefore it is the Examiner's position that the instantly claimed x-ray diffraction peak is present in the film of Marcus, since the film of Marcus has the same structure and the same characteristics as instantly claimed.

Marcus et al. teach the use of a cleaved MgO substrate, as well as that the cleavage technique is a modification of well known cleaved silicon substrates (pg. 3122, col. 1, lines 1-3). Marcus et al. teach the use of their single crystal tantalum film in the semiconductor integrated circuit industry (pg 3121, col. 1). Marcus et al. fail to teach a silicon substrate.

Menzel et al. teach a single crystal tantalum film formed on a substrate (abstract). Menzel et al. teach that the use of these single crystal tantalum films are well known in the semiconductor integrated circuit industry (col. 1). Menzel et al. teach that the substrate may be ceramics or silicon substrates (col. 2, lines 30).

It would have been obvious to one of ordinary skill in the art at the time of the present invention to modify Marcus et al.'s substrate of cleaved MgO, to be a silicon substrate, as Menzel et al. have shown that silicon substrates are known substrates in the semiconductor industry for supporting single crystal tantalum films, and also are known alternatives to ceramic substrates, inclusive of the ceramic MgO substrate, taught by Marcus et al.

Regarding claims 31, as seen in Table 1, the room temperature resistivity is varied between 15 and 30 micro ohms-cm dependent upon the deposition temperature (Marcus et al. pg. 3124).

Regarding claims 32 and 33, the applicant never positively recites that copper must be present in the film. The claim sets forth that the film has a net diffusion distance of less than 10 nms after annealing with copper at a temperature between 650-750°C for one hour. This limitation is an end effective result, where "if" the film is annealed it will possess these characteristics. Even though Marcus et al. do not teach this characteristic, it is expected that the instantly claimed characteristics of net diffusion will be present in the film of Marcus et al. when annealed with copper, since, as shown above, the films of Marcus et al. are the same as those presently claimed.

Response to Arguments

On pages 6-7 of the remarks, applicant argues that contrary to the examiners position, Ding et al. do not teach amorphous tantalum films with no grain boundaries. Applicant relies on the teaching of Ding et al. col. 2, lines 54-62, which teaches that

tantalum films prepared therein are crystalline and the addition of tantalum nitride layers sandwiched between tantalum layers decreases crystallinity and the composite becomes still "more amorphous and dense", and thus the applicant argues that Ding et al. describe a "less crystalline" tantalum layer. Applicant argues a less crystalline layer is still crystalline not "amorphous".

Claim Language

In response applicant defines "amorphous" in the instant specification pg. 6, line 30, to mean "substantially lacking crystalline structure". "Substantially lacking" is vague, and suggests that some crystalline structure may be present in an amorphous tantalum film. Therefore the applicants are arguing a more narrow definition to "amorphous" than is defined in the specification.

Furthermore, the claim language of claim 34, recites a tantalum film "having" an amorphous microstructure. Therefore even those embodiments that are "less crystalline" and "more amorphous" will have (i.e. "comprise") a portion that has an amorphous microstructure. The applicant is arguing a more narrow definition than the scope of the claim allows, as "having" is interpreted as "comprising" which is open ended claim language which allows for other phases including crystalline phases to be present.

Ding et al.

It is also noted, the whole disclosure of Ding et al. is to forming amorphous tantalum films and to avoid any crystallinity or grain boundaries. Ding et al. describe a dense amorphous tantalum layer (col. 2, lines 41). Ding et al. teach that a TaN layer

formed thereon prevents grain boundaries from forming (col. 2, lines 46). Ding et al. teach the entire barrier layer is amorphous (col. 2, lines 47) and wholly amorphous (col. 3, lines 1-5).

Although Ding et al. may describe one embodiment at col. 2, lines 54-62 that may have some presence of grain boundaries, "applicant must look to the whole reference for what it teaches. Applicant cannot merely rely on the examples and argue that the reference did not teach others." In re Courtright, 377 F.2d 647, 153 USPQ 735,739 (CCPA 1967). As described above, the whole endeavor of Ding et al. is to "Wholly amorphous" (col. 3, lines 4), tantalum barrier layers, wherein grain boundaries are undesirable (col. 2 lines 35-40). "Wholly amorphous", as described by Ding et al., reads on the claimed amorphous tantalum film.

On page 7, applicant points to Figure 3 of Ding et al., noting a presence of (002) diffraction peak for embodiments where Ta/TaN are repeated only 1 or 2x. However, the teachings of Ding et al., of repeating 3x or 4x, results in no (002) diffraction peak present as seen in Figure 3. Applicant must look to the whole reference for what it teaches. Applicant cannot merely rely on the examples and argue that the reference did not teach others. The whole disclosure of Ding et al. is to creating "wholly amorphous" layers, and as seen in Figure 3 no diffraction peak is obtained when repeating the layers 3 or 4 times.

Applicant argues on page 7 that the presently claimed diffraction peak attributes of the invention are not inherent in the teachings of Ding as the material disclosed therein is a crystalline composite of Ta and TaN. However, it is noted that "the

arguments of counsel cannot take the place of evidence in the record", *In re Schulze*, 346 F.2d 600, 602, 145 USPQ 716, 718 (CCPA 1965). It is the examiner's position that the arguments provided by the applicant regarding that the presently claimed diffraction peak attributes of the invention are not inherent in the teachings of Ding, must be supported by a declaration or affidavit. As set forth in MPEP 716.02(g), "the reason for requiring evidence in a declaration or affidavit form is to obtain the assurances that any statements or representations made are correct, as provided by 35 U.S.C. 24 and 18 U.S.C. 1001".

Support for the examiners position that as the 002 diffraction peak disappears the diffuse x-ray diffraction peak at $2\theta = 30\text{-}35^{\circ}$ grows stronger, is found in Figure 1 on page 223 of Tsukimoto et al. ("Microstructure of Amorphous Tantalum Nitride thin films"). The claimed x--ray diffraction characteristics are an inherent characteristic to amorphous tantalum based films. Applicant is invited to show evidence that the claimed x-ray characteristics, are not present in the "wholly amorphous" tantalum/tantalum nitride barrier layers of Ding et al.

<u>Stavrev et al and Menzel et al.</u>

On page 7 of the remarks applicant argues against Stavrev et al. arguing that Stavrev et al. teaches Amorphous like films and not amorphous films as claimed. However, these arguments are not found persuasive, as the rejections based on Stavrev et al. are against claims the claims directed to single crystalline tantalum.

Applicant argues that Menzel et al. only teach site specific crystallization and that one of ordinary sill in the art would have no motivation to employ this approach to prepare a crystal film of tantalum.

Menzel et al. teach three dimensional amorphous films, that is, they have a width, length, and thickness (see figures) wherein portions of these films are converted to single crystalline regions. These regions are still films. No where in the specification or the claims does the applicant define that a “film” must cover the entire substrate. Furthermore, Menzel et al. teach that any shape can be converted to monocrystalline as set forth in the rejection above. Therefore there is nothing limiting Menzel et al. from converting the entire surface to monocrystalline tantalum. When Stavrev et al. is combined with Menzel et al. the claimed structure is taught, and therefore the arguments are not found persuasive.

<u>Marcus et al. and Menzel et al.</u>

On page 8 of the remarks, applicant argues that Marcus et al. is directed to deposition of tantalum on cleaved MgO. Applicant further argues that Menzel et al. is directed to patterned regions of single crystalline tantalum not a film.

In response Menzel et al. is not relied upon for its teaching of deposition parameters, rather Menzel et al. is relied upon for its teaching of silicon substrates in the semiconductor industry for supporting single crystalline tantalum, and the obvious substitution of silicon for cleaved MgO, especially in light of Marcus et al.’s, the primary

references, teaching that silicon is known in the same art. Therefore the arguments are not found persuasive.

In response to applicant's arguments against the references individually, one cannot show nonobviousness by attacking references individually where the rejections are based on combinations of references. See *In re Keller*, 642 F.2d 413, 208 USPQ 871 (CCPA 1981); *In re Merck & Co.,* 800 F.2d 1091, 231 USPQ 375 (Fed. Cir. 1986). While Marcus et al. may not teach a specific example of Silicon as the substrate, they suggest that silicon is a known substrate. Further Menzel et al.'s is relied upon to cure this deficiency of Marcus et al., since Menzel et al. teach that silicon for supporting single crystalline tantalum films, in semiconductor applications, similar to those disclosed by Marcus et al., are known in the art at the time of the present invention. And further that Menzel et al. teach that silicon substrates are obvious alternatives to ceramic substrates, inclusive of MgO, in the same art.

Conclusion

Any inquiry concerning this communication or earlier communications from the examiner should be directed to JONATHAN LANGMAN whose telephone number is (571)272-4811. The examiner can normally be reached on Mon-Thurs 8:00 am - 6:30 pm EST.

If attempts to reach the examiner by telephone are unsuccessful, the examiner's supervisor, Jennifer McNeil can be reached on 571-272-1540. The fax phone number for the organization where this application or proceeding is assigned is 571-273-8300.

Information regarding the status of an application may be obtained from the Patent Application Information Retrieval (PAIR) system. Status information for published applications may be obtained from either Private PAIR or Public PAIR. Status information for unpublished applications is available through Private PAIR only. For more information about the PAIR system, see http://pair-direct.uspto.gov. Should you have questions on access to the Private PAIR system, contact the Electronic Business Center (EBC) at 866-217-9197 (toll-free). If you would like assistance from a USPTO Customer Service Representative or access to the automated information system, call 800-786-9199 (IN USA OR CANADA) or 571-272-1000.

JCL
/Jonathan C Langman/
Primary Examiner, Art Unit 1784